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Jimmy L. Funke, Esq.
Delphi Technologies, Inc.
Mail Code 480410202
P.O. Box 5052
Troy, MI 48007

EXAMINER	
CHUO, TONY SHENG HSIANG	
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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	**Application No.** 10/824,719	**Applicant(s)** SCHUBERT ET AL.	
	Examiner Tony Chuo	**Art Unit** 1795	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 22 December 2009.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-11,13-24 and 38-49* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-11,13-24 and 38-49* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Response to Amendment

1. Claims 1-11, 13-24, and 38-49 are currently pending. Claims 12 and 25-37 are cancelled. The previous objection to claim 13 is withdrawn. The amendment to claim 41 does not overcome the previously stated 112, 1st paragraph of claim 41. The 112, 2nd paragraph rejection of claim 41 is withdrawn. The amended claims do overcome the previously stated 103 rejections. However, upon further consideration, claims 1-11, 13-24, and 38-49 are rejected under the following new 112 and 103 rejections. This action is made FINAL as necessitated by the amendment.

Claim Rejections - 35 USC § 112

2. The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

3. Claim 41 is rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. Paragraph [0049] of the specification states “The remaining nanocrystals, shown as 55/212 in FIGS. 4 and 5, are approximately 5 to 10 nm in extent, and represent interconnected islands of single-crystal silicon within a

voided space”. Paragraph [0071] of the specification states “Preferably, to achieve storage capacity on the order of 10% (weight of hydrogen to weight of silicon matrix), the feature size of the silicon should be on the order of 10 Angstroms, or 1 nanometer, as in the <u>silicon columns</u> 202 discussed above.” However, there is no support in the specification for structures within the interior of the porous silicon that have feature sizes of about one nanometer.

4. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

5. Claims 1-7, 17-24, 38, 39, and 41-46 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. It is unclear what the phrase “one or more light sources that emit sufficient photonic energy at a wavelength at which said porous silicon is sufficiently transparent” is referring to since silicon is not known to be transparent.

Claim Rejections - 35 USC § 103

6. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

7. Claims 1, 3-5, 19-24, 38, 39, and 42-45 are rejected under 35 U.S.C. 103(a) as being unpatentable over Redmond (US 2004/0016769) in view of Winstel (US 4265720)

and Northrup et al (US 5882496), and further in view of Yamazaki et al (US 2003/0170939) and as evidenced by Woo et al (US 5926711).

The Redmond reference discloses a hydrogen storage and recovery system “100” comprising a cassette “110” (housing); an opening connected to the cassette for conducting hydrogen gas into and conducting hydrogen gas out of the housing; a hydrogen storing material "115" enclosed within the cassette; a heating system for releasing hydrogen from the hydrogen storing material from the cassette through the opening; and an information processing and control system that is used to control or regulate hydrogen generation that includes sensors that sense the operating conditions of the system and adjusts the conditions within the cassette such as increasing the amount of heat supplied to the cassette in order to achieve an elevated temperature in the cassette and an increased release of hydrogen gas (See paragraphs [0044],[0064], [0073],[0080]). Examiner’s note: According to the specification of the present application, “The silicon activation energies, i.e., the adsorption and desorption energies of hydrogen on silicon, must also be controlled. This is accomplished through one or more techniques comprising … temperature activation …”. In other words, by controlling the temperature of the hydrogen storing material, the silicon activation energy is also inherently controlled. Therefore, the control system and heating system taught by Redmond implicitly controls the activation energy of hydrogen by controlling the temperature of the hydrogen storing material. In addition, the heating system is an equivalent structure for causing the chemisorbed hydrogen atoms to be liberated from

the dangling bond sites to be released as hydrogen gas from the housing through the at least one passage.

However, Redmond does not expressly teach a hydrogen storage member comprising a mass of silicon, wherein the silicon is in a monocrystalline form or a polycrystalline form. The Winstel reference discloses a hydrogen storage material that is a silicon material that is in a finely crystalline form (See column 1, lines 40-47). Examiner's note: It is well known in the art that crystalline silicon can be formed in a monocrystalline form or polycrystalline form.

Therefore, the invention as a whole would have been obvious to one of ordinary skill in the art at the time the invention was made because the disclosure of Winstel indicates that crystalline silicon is a suitable material for use as a hydrogen storage material. The selection of a known material based on its suitability for its intended use has generally been held to be *prima facie* obvious (MPEP §2144.07). As such, it would be obvious to use crystalline silicon.

However, Redmond as modified by Winstel does not expressly teach a porous silicon having an interior defining interior surfaces of the porous silicon and an exterior defining exterior surfaces of the porous silicon, wherein at least the interior surfaces have dangling bond sites at which reversible chemisorption of hydrogen atoms occurs, wherein the interior surfaces of the porous silicon have etched pits, wherein at least interior surfaces are bare silicon surfaces at which the dangling bond sites are exposed, wherein the porous silicon has been treated by a process selected from the group consisting of crushing, milling, treatment with hydrofluoric acid and methanol in the

presence of electric current, treatment with potassium hydroxide, treatment with hydrazine, wet etching, dry etching, deposition of a noble metal such as palladium or platinum, conformal vapor deposition of silicon, and non-conformal vapor deposition of silicon, wherein the porous silicon is derived from molten silicon by crystallization, and wherein the porous silicon is derived from silicon waste obtained from a silicon process waste stream.

The Northrup reference discloses a porous silicon structure that is formed by electrochemically etching a crystalline silicon substrate or wafer “10” with a hydrogen fluoride solution (wet etching), wherein the porous silicon adsorbs gas and desorbs gas upon increase in temperature by a heater (releasing means), and wherein the porous silicon is formed on a silicon wafer (See column 3, lines 43-64 and column 4, lines 50-52). Examiner’s note: The process of etching the surface of the silicon layer inherently forms an interior defining interior surfaces of the silicon layer and an exterior defining exterior surfaces of the silicon layer, wherein pores (etched pits) formed have interior surfaces that are bare silicon surfaces. It is also inherent that the porous silicon defines a layer within at least a first surface portion of the hydrogen storage member. In addition, as evidenced by Woo et al, the process of wet etching the surface of a silicon film with HF, cleans the surface of the silicon film to form a bare silicon surface such that hydrogen bonds to the surface of the silicon film in dangling bond type (See column 4, lines 20-28). Further, it is noted that claims 23 and 24 are being construed as product-by-process and that the product itself does not depend on the process of making it. Accordingly, in a product-by-process claim, the patentability of a product

does not depend on its method of production. The claims are obvious as it has been held similar products claimed in product-by-process limitations are obvious (In re Brown 173 USPQ 685 and In re Fessman 180 USPQ 324, See MPEP 2113: Product-by-Process claims).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Redmond/Winstel hydrogen storage material to include a porous silicon having an interior defining interior surfaces of the porous silicon and an exterior defining exterior surfaces of the porous silicon, wherein at least the interior surfaces have dangling bond sites at which reversible chemisorption of hydrogen atoms occurs, wherein the interior surfaces of the porous silicon have etched pits, wherein at least interior surfaces are bare silicon surfaces at which the dangling bond sites are exposed, wherein the porous silicon has been treated by a process such as wet etching in order to utilize a high surface area porous silicon structure that significantly augments the adsorption and desorption of gases (See Abstract).

However, Redmond as modified by Winstel and Northrup et al does not expressly teach a releasing means comprising one or more light sources that emit sufficient photonic energy at a wavelength at which the porous silicon is sufficiently transparent and the photonic energy is sufficiently absorbed by the chemisorbed hydrogen atoms to promote liberation of the chemisorbed hydrogen atoms from the dangling bond sites, or one or more voltage sources that create an electric field sufficient to affect the silicon activation energies and promote liberation of the chemisorbed hydrogen atoms from the dangling bond sites, or combinations thereof.

The Yamazaki reference teaches the concept of breaking Si-H bonds by radiation of a beam emitted from a light source such as a laser or a halogen lamp (See paragraph [0049]). Examiner's note: It is inherent that a light source such as a laser emits sufficient photonic energy at a wavelength at which the porous silicon is sufficiently transparent and the photonic energy is sufficiently absorbed by the chemisorbed hydrogen atoms to promote liberation of the chemisorbed hydrogen atoms from the dangling bond site because a light source that breaks Si-H bonds also emits photonic energy that is sufficient to promote the liberation of chemisorbed hydrogen atoms. It is also inherent that a light source such as a laser would pass photonic energy through the hydrogen storage material (porous silicon).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to substitute the Redmond/Winstel/Northrup method of releasing hydrogen with a releasing means that is one or more light sources that emit sufficient photonic energy at a wavelength at which the porous silicon is sufficiently transparent and the photonic energy is sufficiently absorbed by the chemisorbed hydrogen atoms to promote liberation of the chemisorbed hydrogen atoms from the dangling bond sites because the substitution of one known method of initiating hydrogen desorption for another would have yielded predictable results to one of ordinary skill in the art at the time of the invention.

8. Claim 2 is rejected under 35 U.S.C. 103(a) as being unpatentable over Redmond (US 2004/0016769) in view of Winstel (US 4265720), Northrup et al (US 5882496), and

Yamazaki et al (US 2003/0170939) as applied to claim 1 above, and further in view of Gore et al (US 2004/0048466).

However, Redmond as modified by Winstel, Northrup, and Yamazaki does not expressly teach at least the interior surfaces of the porous silicon that have dendritic spikes or non-conformal growth formed by an additive silicon deposition process. The Gore reference teaches the concept of creating a textured silicon surface with surface features having at least one of various shapes including grassy, spiked, or bristled (See paragraph [0009]. Examiner's note: The spiked shape surface features taught by Gore are construed as non-conformal growth. In addition, the limitation "formed by an additive silicon deposition process" is not given patentable weight because in a product by process claim, the product itself does not depend on the process of making it.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Redmond/Winstel/Northrup hydrogen storage material to include at least the interior surfaces of the porous silicon that have non-conformal growth in order to further increase the storage capacity of hydrogen by increasing the surface area of the porous silicon (See Abstract). Examiner's note: It is well known in the art that increasing the surface area of a hydrogen storage member results in increasing the storage capacity of the hydrogen storage member.

9. Claim 6 is rejected under 35 U.S.C. 103(a) as being unpatentable over Redmond (US 2004/0016769) in view of Winstel (US 4265720), Northrup et al (US 5882496), and Yamazaki et al (US 2003/0170939) as applied to claims 1 and 5 above.

However, Redmond as modified by Winstel, Northrup, and Yamazaki does not expressly teach a percent void volume of the surface layer that is about 50%.

However, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the Winstel/Northrup/Yamazaki porous silicon structures to include a percent void volume of the surface layer that is about 50% because it has been held that the discovery of an optimum value of a result effective variable in a known process is ordinarily within the skill of the art. *In re Boesch*, 205 USPQ 215 (CCPA 1980). The percent void volume is a result effective variable of increasing the surface area of the porous silicon structure. In addition, there is no evidence of the criticality of the percent void volume.

10. Claim 7 is rejected under 35 U.S.C. 103(a) as being unpatentable over Redmond (US 2004/0016769) in view of Winstel (US 4265720), Northrup et al (US 5882496), and Yamazaki et al (US 2003/0170939) as applied to claims 1 and 5 above, and further in view of Wagner et al (US 5196377).

However, Redmond as modified by Winstel, Northrup, and Yamazaki does not expressly teach electronic integrated circuits on a second surface portion of the hydrogen storage member. The Wagner reference discloses integrated circuits that are placed inside cavities of a silicon wafer “10” (See column 11, lines 12-16).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the Redmond/Winstel/Northrup/Yamazaki porous silicon structures to include electronic integrated circuits on a second surface portion of the hydrogen storage member in order to utilize well known integrated circuit

processing techniques to provide a silicon wafer-based integrated circuit carrier offering high density packaging with high yield processes. In addition, one skilled in the art could have combined the elements as claimed by known methods with no change in their respective functions, and the combination would have yielded nothing more than predictable results to one of ordinary skill in the art at the time of the invention.

11. Claims 8 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Winstel (US 4265720) in view of Kornilovich (US 7135057) and Northrup et al (US 5882496), and further in view of Gore et al (US 2004/0048466) and as evidenced by Woo et al (US 5926711).

The Winstel reference discloses a system for storing and retrieving hydrogen comprising: a housing “4”; a passage connected to the housing for conducting hydrogen gas into and conducting hydrogen gas out of the housing; a hydrogen storage member “5” enclosed within the housing that is a silicon material in a finely crystalline form; an operative valve control means “6”; and implicitly a heating means for discharging hydrogen gas from the housing through the passage (See column 2, lines 63-67, column 3, lines 40-48, and Figure 2). Examiner’s note: The valve “6” and heating means disclosed by Winstel are construed as an equivalent structure for liberating chemisorbed hydrogen atoms from the dangling bond sites and releasing the liberated hydrogen atoms as hydrogen gas.

However, Winstel does not expressly teach a hydrogen storage member comprising a porous mesh of silicon columns, wherein the silicon columns have cross-sectional shapes of a circle. The Kornilovich reference teaches a hydrogen storage

medium that is made of a large pile of silicon nanowires that are in the shape of a column having cross-sectional shape of a circle such that the hydrogen storage medium has porosity (See column 3, lines 27-31). In addition, it also discloses that the storage efficiency of the hydrogen storage medium improves with decreasing nanowire radius (silicon column diameter) (See column 3, lines 31-33).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Winstel system for storing and retrieving hydrogen to include a hydrogen storage member comprising a porous mesh of silicon columns, wherein the silicon columns have cross-sectional shapes of a circle in order to improve the storage efficiency of the hydrogen storage medium and to allow fast diffusion of gas molecules such as hydrogen gas. In addition, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the Winstel/Kornilovich hydrogen storage medium to include silicon columns having diameters of about 1 nanometer because it has been held that the discovery of an optimum value of a result effective variable in a known process is ordinarily within the skill of the art. *In re Boesch*, 205 USPQ 215 (CCPA 1980). The diameter of the silicon column is a result effective variable of increasing the storage efficiency of silicon columns because the smaller the diameter of the silicon column, the larger the overall surface area of the storage medium.

However, Winstel as modified by Kornilovich does not expressly teach a hydrogen storage member comprising a silicon material having silicon surfaces with dangling bond sites at which reversible chemisorption of hydrogen atoms occurs. The

Northrup reference discloses a porous silicon structure that is formed by electrochemically etching a crystalline silicon substrate or wafer “10” with a hydrogen fluoride solution (See column 3, lines 61-64 and column 4, lines 50-52). Examiner’s note: As evidenced by Woo et al, the process of wet etching the surface of a silicon film with HF, cleans the surface of the silicon film to form a bare silicon surface such that hydrogen bonds to the surface of the silicon film in dangling bond type (See column 2 line 65 to column 3 line 2).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Winstel/Kornilovich system for storing and retrieving hydrogen to include a hydrogen storage member comprising a silicon having surfaces with dangling bond sites at which reversible chemisorption of hydrogen atoms occurs in order to increase the surface area of the silicon columns, thereby significantly augmenting the adsorption and desorption of the hydrogen gas.

However, Winstel as modified by Kornilovich and Northrup does not expressly teach silicon columns having dendritic spikes or non-conformal growth formed by an additive silicon deposition process. The Gore reference teaches the concept of creating a textured silicon surface with surface features having at least one of various shapes including grassy, spiked, or bristled (See paragraph [0009]. Examiner’s note: The spiked shape surface features taught by Gore are construed as non-conformal growth. In addition, the limitation “formed by an additive silicon deposition process" is not given patentable weight because in a product by process claim, the product itself does not depend on the process of making it.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Winstel/Kornilovich/Northrup hydrogen storage material to include at least the interior surfaces of the porous silicon that have non-conformal growth in order to further increase the storage capacity of hydrogen by increasing the surface area of the silicon columns (See Abstract). Examiner's note: It is well known in the art that increasing the surface area of a hydrogen storage member results in increasing the storage capacity of the hydrogen storage member.

12. Claims 9-11 are rejected under 35 U.S.C. 103(a) as being unpatentable over Winstel (US 4265720) in view of Kornilovich (US 7135057), Northrup et al (US 5882496), and Gore et al (US 2004/0048466) as applied to claim 8 above, and further in view of Kim (US 2002/0158284).

However, Winstel as modified by Kornilovich, Northrup, and Gore does not expressly teach silicon columns that are formed by extrusion of molten silicon to have surfaces on the (111) plane, wherein the silicon columns are extruded through at least one aperture that is an integral multiple of the lattice spacing of silicon such that the silicon columns have a minimum energy configuration suitable for forming a crystal. The Kim reference discloses that typically silicon wafers have a (100) orientation on the top surface and the exposed silicon near the trenches has a (111) orientation, wherein the (111) orientation has a larger number of dangling bonds (See paragraph [0006]). Examiner's note: It is contended by the examiner that silicon columns that have the (111) orientation also have a minimum energy configuration suitable for forming a crystal. Therefore, the Kim reference implicitly teaches that limitation. In addition, it is

noted that claims 10 and 11 are being construed as product-by-process and that the product itself does not depend on the process of making it. Accordingly, in a product-by-process claim, the patentability of a product does not depend on its method of production. The claims are obvious as it has been held similar products claimed in product-by-process limitations are obvious (In re Brown 173 USPQ 685 and In re Fessman 180 USPQ 324, See MPEP 2113: Product-by-Process claims).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the Winstel/Kornilovich/Northrup/Gore system for storing and retrieving hydrogen to include silicon columns that are formed by extrusion of molten silicon to have surfaces on the (111) plane, wherein the silicon columns are extruded through at least one aperture that is an integral multiple of the lattice spacing of silicon such that the silicon columns have a minimum energy configuration suitable for forming a crystal in order to utilize a silicon material orientation that has a greater number of dangling bonds, thereby increasing the storage efficiency of the hydrogen storage material.

13. Claim 14 is rejected under 35 U.S.C. 103(a) as being unpatentable over Winstel (US 4265720) in view of Kornilovich (US 7135057), Northrup et al (US 5882496), Gore et al (US 2004/0048466), and Kim (US 2002/0158284) as applied to claim 10 above, and further in view of Anthony et al (US 6040230).

However, Winstel as modified by Kornilovich, Northrup, Gore, and Kim does not expressly teach silicon columns that have roughened surface. The Anthony reference

teaches the concept of etching polysilicon structures “306” in order to roughen the surface (See column 6, lines 6-10).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the Winstel/Kornilovich/Northrup/Gore/Kim system for storing and retrieving hydrogen to include silicon columns that have roughened surface in order to enhance the surface area of the silicon columns and further improve the storage efficiency.

14. Claims 15, 16, 40, and 48 are rejected under 35 U.S.C. 103(a) as being unpatentable over Winstel (US 4265720) in view of Kornilovich (US 7135057), Northrup et al (US 5882496), and Gore et al (US 2004/0048466) applied to claim 8 above, and further in view of Redmond (US 2004/ 0016769).

However, Winstel as modified by Kornilovich, Northrup, and Gore does not expressly teach a control unit comprising means for receiving inputs indicative of operating parameters of the system and means for issuing outputs that control the liberating means, wherein the control unit comprises means for controlling the silicon activation energy of hydrogen on the porous mesh of crystalline silicon columns of the hydrogen storage member. The Redmond reference discloses a hydrogen storage and recovery system “100” comprising an information processing and control system that is used to control or regulate hydrogen generation that includes sensors that sense the operating conditions of the system and adjusts the conditions within the cassette such as increasing the amount of heat supplied to the cassette in order to achieve an elevated temperature in the cassette and an increased release of hydrogen gas (See

paragraphs [0044],[0064], [0073],[0080]). Examiner's note: According to the specification of the present application, "The silicon activation energies, i.e., the adsorption and desorption energies of hydrogen on silicon, must also be controlled. This is accomplished through one or more techniques comprising … temperature activation …". In other words, by controlling the temperature of the hydrogen storing material, the silicon activation energy is also inherently controlled. Therefore, the control system and heating system taught by Redmond implicitly controls the activation energy of hydrogen by controlling the temperature of the hydrogen storing material.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the Winstel/Kornilovich/Northrup/Gore system for storing and retrieving hydrogen to include a control unit comprising means for receiving inputs indicative of operating parameters of the system and means for issuing outputs that control the liberating means, wherein the control unit comprises means for controlling the silicon activation energy of hydrogen on the porous mesh of crystalline silicon columns of the hydrogen storage member in order to utilize a control system that more accurately and efficiently supplies hydrogen to a hydrogen utilizing system.

15. Claim 17 is rejected under 35 U.S.C. 103(a) as being unpatentable over Redmond (US 2004/0016769) in view of Winstel (US 4265720), Northrup et al (US 5882496), and Yamazaki et al (US 2003/0170939) as applied to claim 1 above, and further in view of Ota et al (US 6540377).

However, Redmond as modified by Winstel, Northrup, and Yamazaki does not expressly teach a releasing means comprising a light emitting diode. The Ota reference teaches a light source that is a light emitting diode (See Abstract).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Redmond/Winstel/Northrup/Yamazaki fuel cell system to include a releasing means comprising a light emitting diode because the substitution of one known type of light source for another would have yielded predictable results to one of ordinary skill in the art at the time of the invention.

16. Claim 46 is rejected under 35 U.S.C. 103(a) as being unpatentable over Redmond (US 2004/0016769) in view of Winstel (US 4265720), Northrup et al (US 5882496), and Yamazaki et al (US 2003/0170939) as applied to claim 1 above, and further in view of Yamazaki et al (US 6964890).

However, Redmond as modified by Winstel, Northrup, and Yamazaki does not expressly teach a releasing means comprising a voltage source that liberates the chemisorbed hydrogen atoms form the dangling bond sites by creating an electric field across the porous silicon. The Yamazaki '890 reference teaches the concept of applying electric voltage or current to a semiconductor such as silicon to desorb hydrogen from the semiconductor (See column 2, lines 38-45).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Redmond/Winstel/Northrup/Yamazaki fuel cell system to include a releasing means comprising a voltage source that liberates the chemisorbed hydrogen atoms form the dangling bond sites by creating an electric field

across the porous silicon because the substitution of one known method of initiating hydrogen desorption for another would have yielded predictable results to one of ordinary skill in the art at the time of the invention.

17. Claim 47 is rejected under 35 U.S.C. 103(a) as being unpatentable over Winstel (US 4265720) in view of Kornilovich (US 7135057), Northrup et al (US 5882496), and Gore et al (US 2004/0048466) as applied to claims 8 above, and further in view of Yamazaki et al (US 2003/0170939).

However, Winstel as modified by Kornilovich, Northrup, and Gore does not expressly teach a liberating means that comprises a light source that liberates the chemisorbed hydrogen atoms from the dangling bond sites by passing photonic energy through the porous mesh. The Yamazaki reference teaches the concept of breaking Si-H bonds by radiation of a beam emitted from a light source such as a laser or a halogen lamp (See paragraph [0049]). Examiner's note: It is inherent that a light source such as a laser promotes the liberation of the chemisorbed hydrogen atoms from the dangling bond sites by passing photonic energy through the porous mesh because a light source that breaks Si-H bonds also emits photonic energy that is sufficient to promote the liberation of chemisorbed hydrogen atoms.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the Winstel/Kornilovich/Northrup/Gore system to include a liberating means that comprises a light source that liberates the chemisorbed hydrogen atoms from the dangling bond sites by passing photonic energy through the porous mesh because the substitution of one known method of liberating hydrogen

atoms for another would have yielded predictable results to one of ordinary skill in the art at the time of the invention.

18. Claim 49 is rejected under 35 U.S.C. 103(a) as being unpatentable over Winstel (US 4265720) in view of Kornilovich (US 7135057), Northrup et al (US 5882496), and Gore et al (US 2004/0048466) as applied to claim 8 above, and further in view of Yamazaki et al (US 6964890).

However, Winstel as modified by Kornilovich, Northrup, and Gore does not expressly teach a liberating means comprising a voltage source that promotes the liberation of the chemisorbed hydrogen atoms form the dangling bond sites by creating an electric field across the porous mesh. The Yamazaki reference teaches the concept of applying electric voltage or current to a semiconductor such as silicon to desorb hydrogen from the semiconductor (See column 2, lines 38-45).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Winstel/Kornilovich/Northrup/Gore fuel cell system to include a liberating means comprising a voltage source that promotes the liberation of the chemisorbed hydrogen atoms form the dangling bond sites by creating an electric field across the porous mesh because the substitution of one known method of liberating hydrogen atoms for another would have yielded predictable results to one of ordinary skill in the art at the time of the invention.

Allowable Subject Matter

19. Claim 18 is objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims and if the 112, 2nd paragraph rejection is obviated.

Response to Arguments

20. Applicant's arguments filed 12/22/09 have been fully considered but they are not persuasive.

The applicants argue that paragraph [0071] discloses porous silicon (55,212) formed from comminuted silicon, and not silicon columns (202) as stated in the Office Action.

In response, as stated above in the 112, 1st paragraph rejection, the specification does not provide support for structures within the interior of the porous silicon that have feature sizes of about one nanometer.

The applicants further argue that Gore spikes are not equivalent to Applicants' claimed dendritic spike or non-conformal growth, and are not formed by an additive process.

In response, the Gore spikesare construed as non-conformal growth because the term “non-conformal growth” is given the broadest reasonable interpretation which is a structure extends from a substrate that increases the surface area of the substrate. In

addition, although Gore's process is subtractive, claim 2 is construed as being product-by-process. Therefore, the product itself does not depend on the process of making it.

The applicants further argue that Yamazaki cannot be relied on to teach anything regarding hydrogen desorption from silicon, at least as it pertains to hydrogen storage as taught by Applicants and other prior art of record.

In response, the examiner maintains the contention that the Yamazaki teaching of breaking the bond between hydrogen and silicon by applying an electric voltage or current is applicable to hydrogen desorption from silicon as it pertains to hydrogen storage because breaking the hydrogen-silicon bond liberates/releases hydrogen from the dangling bond sites of porous silicon.

The applicants further argue that Yamazaki clearly teaches the desorption of hydrogen by applying an electric voltage or current to heat silicon (column 2, lines 43-46), which again is not the releasing/liberating means recited in independent claim 1 and dependent claims 17, 18, 38, 44, and 46.

In response, there is no limitation in the claims that precludes the heating of silicon by applying an electric voltage or current. Claim 1 recites "voltage sources that create an electric field sufficient to affect the silicon activation energies and promote liberation of the chemisorbed hydrogen atoms from the dangling bond sites" so there is no requirement that the creating the electric field cannot heat the silicon. Therefore, the examiner maintains that the Yamazaki teaching of applying an electric voltage to silicon reads on the claims because hydrogen is desorbed or liberated from the dangling bond sites as a result of applying the electric voltage to the silicon.

The applicants further argue that the Office Action does not cite any of the references as teaching “silicon columns have a minimum energy configuration” or how this characteristic is relevant to hydrogen absorption/desorption.

In response, the Kim reference discloses silicon that have surfaces on the (111) plane. The examiner contends that silicon that has surfaces on the (111) plane also has a minimum energy configuration.

The applicants further argue that Anthony was cited for etching polysilicon structures "with oxygen in order to roughen the surface." However, those skilled in the art would not look to such teachings in order to modify the teachings of Kornilovich, Northrup or Kim, since the oxygen etch would tie up the dangling bonds required to desorb hydrogen by forming oxygen-silicon bonds that are stronger than hydrogen-silicon bonds.

In response, the Anthony reference is relied upon for the teaching of enhancing the surface area of silicon by etching the surface to roughen the surface. Therefore, one skilled in the art would know that a different etchant should be used if the silicon is being used as a hydrogen storage material.

Conclusion

Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Tony Chuo whose telephone number is (571)272-0717. The examiner can normally be reached on M-F, 9:00AM to 5:30PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jennifer Michener can be reached on (571) 272-1424. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a

USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

TC

/Jonathan Crepeau/
Primary Examiner, Art Unit 1795